UNIVERSITI PUTRA MALAYSIA

COLLOID-SURFACE CHARACTERISTICS AND AMELIORATION PROBLEMS OF SOME VOLCANIC SOILS IN WEST SUMATRA, INDONESIA

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By

DIAN FIANTIS

Thesis Submitted in Fulfilment of the Requirements for the Degree Doctor of Philosophy in the Faculty of Agriculture Universiti Putra Malaysia

June 2000

DEDICATION

This thesis is dedicated to my beloved parents

Hj. Suarni

and

late H. Zubir Latif

who always supported and encouraged me to do the best.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

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Chairman : Prof. Dr. J. Shamshuddin

Faculty : Agriculture, UPM

Co-chairman : Prof. Dr. E. Van Ranst

Faculty : Science, Ghent University, Belgium.

Andisols from elevational transects at Mt. Marapi and Mt. Pasaman in West Sumatra, Indonesia were studied to characterize their physico-chemical and mineralogical properties. These soils are developed under a udic, isothermic and isohyperthermic climatic regime. They have dark epipedons with high contents of organic carbon and low bulk densities (< 0.9 Mg m^{-3}). All the nine pedons studied were found to meet the physical and chemical criteria of andic materials.

Major minerals in the sand fraction are quartz, plagioclase, hornblende, augite, hypersthene, olivine and volcanic glass. Some of the volcanic glass is coated with amorphous materials. Allophane, cristobalite, feldspars and halloysite

are major minerals in the clay fraction. Some soils contain imogolite. Halloysite exists as tubular crystals. Gibbsite is found in Mt. Pasaman soils, while opaline silica is present in the surface horizons of Mt. Marapi soils.

The P sorption characteristics of the soils were described using Langmuir and Freundlich equations. The Langmuir phosphorus sorption maxima ranged from 856 to 2,051 mg P kg^{-1} and the Freundlich phosphurus sorption maxima ranged from 300 to 2,500 mg P kg^{-1}. Mt. Pasaman soils have higher P sorption than Mt. Marapi soils due to higher allophane content in the former soils. By using stepwise regression analysis, the combination of Al_0, Si_0, Fe_0 and Al_d predicted more than 88 % of the variation in the P sorption. The external P requirements were between 300 to 2,700 mg P kg^{-1} for Mt. Marapi soils and between 2,300 to 7,800 mg P kg^{-1} for Mt. Pasaman soils.

Superphosphate and Ca-silicate applications have some effects on the soils. pH_0 changed after these amendments were applied. Phosphate application lowered pH_0 and increased CEC. Application of Ca-silicate increased pH_0 initially. Later it decreased. Application of Ca-silicate at 120 t ha^{-1} decreased P sorption by 96 % while the external P requirement was reduced by 90 %.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Dokto Falsafah

SIFAT-SIFAT PERMUKAAN KOLOID DAN MASALAH AMELIORASI PADA TANAH VULKANIK DI SUMATRA BARAT, INDONESIA

Oleh

DIAN FIANTIS

June 2000

Pengurusi : **Prof. Dr. J. Shamshuddin**

Faculti : **Pertanian, UPM**

Pengurusi-bersama : **Prof. Dr. E. Van Ranst**

Fakulti : **Sains, Ghent University, Belgium.**

Sifat fizik-kimia dan mineralogi tanah Andisols daripada beberapa ketinggian di Gunung Marapi dan Gunung Pasaman di daerah Sumatra Barat, Indonesia telah dikaji. Tanah ini terjadi dalam keadaan regim kelembaban udic, isothermik dan isohipertermik. Tanah mempunyai epipedon yang gelap dengan karbon organik tinggi dan ketumpatan pukal rendah (< 0.9 Mg m^{-3}). Kesemua 9 pedon yang dikaji memenuhi kriteria sifat fizik dan kimia andik.

Mineral utama yang dijumpai dalam bahagian pasir ialah kuarsa, plagioklas, hornblen, augit, hypersten, olivin dan gelas vulkan. Sebahagian daripada gelas vulkan dilapisi oleh bahan amorfus. Allophan, kristobalit, feldspars dan haloisit merupakan mineral utama yang terdapat dalam bahagian lempung. Ada beberapa

tanah mengandung imogolit. Haloisit wujud dalam bentuk kristal tiup. Gibsit dijumpai dalam tanah Gunung Pasaman, manakala silika opal wujud di permukaan tanah Gunung Marapi.

Ciri-ciri jerapan P tanah dijelaskan dengan persamaan Langmuir dan Freundlich. Jerapan maksimum P bagi model Langmuir berkisar pada nilai 856 - 2,051 mg P kg^{-1} dan jerapan maksimum P bagi Freundlich pula ialah 300 - 2,500 mg P kg^{-1}. Tanah Gunung Pasaman mempunyai jerapan P yang lebih tinggi jika dibandingkan dengan tanah Gunung Marapi. Dengan menggunakan regresi, kombinasi Al_0, Si_0, Fe_0 dan Al_d dapat meramalkan lebih 88 % daripada variasi jerapan P. Keperluan P ialah antara 300 ke 2,700 mg P kg^{-1} untuk tanah Gunung Marapi dan antara 2,300 ke 7,800 mg P kg^{-1} untuk tanah Gunung Pasaman.

Aplikasi superphosphat dan Ca-silikat mempunyai kesan kepada tanah. pH_0 berubah selepas aplikasi bahan ini. Aplikasi fosfat menurunkan pH_0 dan menaikan KPK. Aplikasi Ca-silikat meningkatkan pH_0 pada mulanya. Kemudian ianya turun. Aplikasi 120 t ha^{-1} Ca-silikat menurunkan jerapan P sebanyak 96 % manakala keperluan P menurun sebanyak 90 %.

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This work hopes to contribute to our limited knowledge concerning the nature and properties of well-drained volcanic ash soils in the humid tropics, in general, and in the West Sumatra of Indonesia, in particular. This thesis is based on my intensive field and laboratory works in the last couple of years. The completion of this thesis would have been impossible without the assistance and direct involvement of so many kindhearted individuals. Thus, I am very much indebted to my present as well as to my previous mentors. I have no way of repaying such a debt except to express my sincerest gratitude.

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I wish to express my heartfelt thanks to my beloved husband 'Nelson' and our precious sons: Tito and Irfan for their patience and understanding. Finally, my deepest gratitude goes to my parents, sisters and brothers for their encouragement and help during my studies and away from home.

I certify that an Examination Committee met on June 8th , 2000 to conduct the final examination of Dian Fiantis on her Doctor of Philosophy thesis entitled "Colloid-Surface Characteristics and Amelioration Problems of Some Volcanic Soils in West Sumatra, Indonesia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date 27 JUN 2000

This thesis submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfilment of the requirements for the degree of Doctor of Philosophy.

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Date 13 JUL 2000

I hereby declare that this thesis is based on my original work except for quotations and citations which, have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

signed

Candidate.

DIAN FIANTIS

Date: 2 6 JUN 2000

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES